DESIGN AND ANALYSIS FRONT HOOD FAIRING FOR CARS

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A report submitted in fulfillment of the requirements

for the award of the Bachelor of

Mechanical Engineering with Automotive Engineering

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

"I hereby declare that I have read this project report and in my opinion this project report is sufficient terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering."

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I Mahasufee Bin Mahazis declare that this report entitled " *Design and Analysis Front Hood Fairing for Cars (Mechanical)* " is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Mahasaufee Bin Mahazis

Date : .....

Dedicated to my beloved abah and emak

ACKNOWLEDGEMENTS

Indeed, the emotional moments have come.

Alhamdulillah, thanks to him for granting me such precious breathing spaces to finally complete my wonderful years of study in UMP. I am truly thankful to you for giving me those huge tests during to complete this research which I believed they will be my greatest teachers ever in order to survive for upcoming moments. Alhamdulillah.

My infinite gratitude goes to both my parents who in my opinion are the best parents in the world and also my family members for their enduring patience, moral and financial supports. Your sacrifices are truly invaluable. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed.

Then, I would like to express my sincere appreciation to my wise supervisor, Mr. Devarajan a/l Ramasamy, who generously shared his insights and suggestions, for his critics, trust, encouragement, and attention. Without his continued support and interest, this project report would not have been the same as presented here. From the bottom of my heart, I want said thank you. Thank you for everything. May God bless all of you.

ABSTRACT

This report is an outcome of the work carried out in doing and completing my final year project, Design and analysis front hood fairing for cars. The paper presents a model of the front hood fairing for cars that can reduce the drag coefficient of the car, model that been used is proton Iswara. The overall duty is modeling and analyzes to get the best model that can reduce the coefficient of drag of the proton Iswara because of the high drag force at front windscreen. It happen when the airflow at the windscreen is disturbed by car wiper during high speed. It is often that the wiper system generates unwanted noise and vibration during the high speed. The report starts off with an introduction in aerodynamics vehicle and design. Then proceed to investigation about the problem at the front windscreen to get information. After gathering all the relevant information, the project undergoes design process. In this steps, from the knowledge gathered before is use to make a design refers to case data that suitable for the project. Several sketches have been made and only a few have been selected based on the suitability of the front hood and dimension of the windscreen. Based on the sketches, all the sketches will be draw into CAD software and simulate in the CFD software. At the end, the fairing that can reduce more coefficient of drag will be selected. The result shown by adding fairing at the front hood will decrease the pressure and wind noise also can be reduced. Then, the airflow will smooth and the performance of the car greater than before.

ABSTRAK

Laporan ini hasil daripada kajian dalam projek sarjana muda yang bertajuk rekaan dan analisis struktur bantu di bonet hadapan untuk kereta. Kertas kerja ini memapaparkan dan menerangkan model struktur bantu di bonet hadapan yang dapat mengurangkan pekali heretan kereta. Model kereta yang digunakan ialah Proton Iswara. Keseluruhan tugas adalah untuk mereka dan menganalisis model-model terus memilih yang terbaik yang dapat mengurangkan daya heretan di kaca hadapan kereta. Ia berlaku akibat aliran udara di bahagian kaca hadapan kereta dihalang oleh wiper semasa pemanduan di halaju yang tinggi . Hal ini sering bahawa sistem wiper menghasilkan hingar dan getaran yang tidak diingini pada kelajuan tinggi. Laporan bermula dengan pengenalan dalam aerodinamik kenderaan dan rekaan. Seterusnya penyiasatan terhadap masalah di bahagian kaca hadapan untuk mendapatkan maklumat lanjut. Apabila semua dokumen berkaitan selesai dikumpul,projek ini diteruskan dengan fasa rekabentuk model. Dalam fasa ini, rekabentuk dilakukan berdasarkan dokumen yang dikumpul serta bersesuaian dengan projek. Beberapa lakaran model dihasilkan dan dipilih mengikut kesesuaian dengan bonet hadapan serta kaca hadapan kereta. Lakaran ini kemudiannya akan di lukis didalam perisian CAD dan di analisis didalam perisian CFD. Model yang dapat mengurangkan pekali seretan paling banyak akan dipilih sebagai struktur bantu yang terbaik. Akhir sekali, struktur bantu yang dapat mengurangkan pekali seretan yang terbaik akan dipilih. Keputusan projek menunjukkan dengan penambahan struktur bantu dapat mengurangkan tekanan dan hingar angin dapat dikurangkan. Kemudian, aliran udara akan lancar dan prestasi kereta yang lebih baik daripada sebelumnya.

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ac	Acceleration
p	Pressure
U	Velocity
ρ	Density
Cp	Coefficient of pressure
v_∞	Stream velocity
D	Drag
D_f	Friction Drag
A	Area
L	Lift
C_L	Coefficient of lift
u	Fluid velocity
S_i	Mass-distributed
E	Total energy per unit mass
Q_H	Heat source per unit volume
τ_{ik}	Viscous shear stress tensor
q_i	Diffusive heat flux

LIST OF ABBREVIATIONS

3-D	Three Dimensional
CAE	*Computer-aided engineering*
CFD	Computational Fluid Dynamics
CAD	Computational Aided Design
RANS	Reynolds-averaged Navier-Stokes equation
DNS	Direct numerical simulation
HEV	Hybrid electric vehicle

CHAPTER 1

INTRODUCTION

1.1 Project Background

The performance, handling, safety and comfort of an automobile are significantly affected by its aerodynamics properties. Defecting drag was the first major focus of automotive aerodynamics, beginning in 1960's. Low drag is important for fuel economy and low emissions. Other aspects of vehicle aerodynamics are no less important for quality of automobiles such as directional stability, wind noise, cooling of engine, ventilating and air conditional these all depend on flow field around and through vehicle.

Nowadays, automotive designer rely on aerodynamics principle to create improvement in the power and handling of vehicle at high speeds. Passenger cars have become more shapely over the years as manufacturer discovered how streamlining can increase fuel efficiency, allowing a car to travel at the same speed using less horsepower. These designs reduce air resistance, or aerodynamics drag. Low drag coefficient make the vehicle enable to move easily through the surrounding viscous air with minimum of resistance. As an increasing of drag, the more power of car to do work than reducing the power train efficiency.

In aerodynamic field there have two major studies need to be concerned where is study the airflow on the body and estimation of drag. To understand the aerodynamics on the HEV model, flow visualization is the best technique as usual does by wind tunnel. But, in this project Computational Fluid Dynamics (CFD) analysis will be used as the technology of computer simulation to estimate the drag of HEV model after conventional technique due to economical factor.

1.2 Problem Statement

A windscreen wiper is a device used to wipe rain and dirt from a windscreen. Almost all motor vehicle, including train, aircraft and watercraft, are equipped with windscreen wiper, which are usually a legal requirement. It is often that the wiper system generates unwanted noise and vibration during the high speed. The high speed flow through the exposed structures of the wiper can cause high wind noise levels [8]. It is because the wiper blocks the airflow through the car body.

Reverse flow also exist when the flow is disturbed by the wiper during the high speed level. The reverse flow will increase the number of drag force. Aerodynamics drag is the force of air along the length of traveling car, opposing the car's force. As the car cuts a path through the air, some air molecules collide with the front windscreen and producing resistance. A passenger car driving on the highway spends an estimated 60 percent of its energy overcoming air drag, a far greater percentage than tire friction and the energy needs of the drive train itself.

Hence, often the only solution available is to hide the wiper by tucking them behind the rear edge of hood or putting them behind some sort of flow deflector. While this does not address the wind noise generated while the wiper are being used, this is less of concern, as the increase in wind noise due to the wipers during a rain storm is usually masked by higher levels of tire noise due to the wet roads and by raindrop impact noise.

In this PSM project, the element that important to be study is aerodynamics. Part that be focused is at the front hood and the windshield of the car. Proton Iswara is car that be chosen as in this project because it is widely used by customer in Malaysia. As reducing the drag and the wind noise problem, the airflow will smooth and the performance of the car greater than before.

1.3 Objectives

1. To design the fairing hood car that make the airflow over the car body is not disturbed by the car wiper.
2. Reducing the drag by addition of fairing at front hood of car.

1.4 Project Scopes

1. Study of Proton Iswara body structure.
2. Modeling software in CAD.
3. Analyze the project with CFD.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory of Aerodynamics

In this section, the fundamental of fluids mechanics and basics of aerodynamics were discussed to improve the understanding in doing analysis of the project. Many studies had been done in flow over bodies, there are many factor that effect the performance of car. In terms of aerodynamics field or fundamental of fluid mechanics the factor that will affect the aerodynamics of car such as Bernoulli's Equation, pressure, lift and drag coefficient, boundary layer, separation flow, and shape dependence were studied.

2.1.1 Bernoulli's Equation

Aerodynamics play main role to defined road vehicle's characteristic like handling, noise, performance and fuel economy [1]. All of these characteristics are influenced by drag force which is ruled by Bernoulli Equation.

$$p + \frac{1}{2}\rho_a U^2 = \text{a constant} \tag{2.1}$$

Basic assumptions of Bernoulli's Equation for an air flows are;

1. Viscous effects are assumed negligible
2. The flow is assumed to be steady

3. The flow is assumed to be incompressible
4. The equation is applicable along streamline

From equation (2.1) shows the increasing of velocity will case the decrease in static pressure and vice versa. It is because these two elements are proportional inversely with each other. On the movement of road vehicle will produce a distribution velocity that's create the skin friction due to viscous boundary layer which act as tangential forces (shear stress) then contribute drag. Besides that, force due to pressure also created which acts perpendicular to the surface then contribute both lift and drag forces. The Bernoulli's Equation from equation (2.1) gives the important result which is [2], [4], [5];

Static pressure + Dynamic Pressure = Stagnation Pressure.

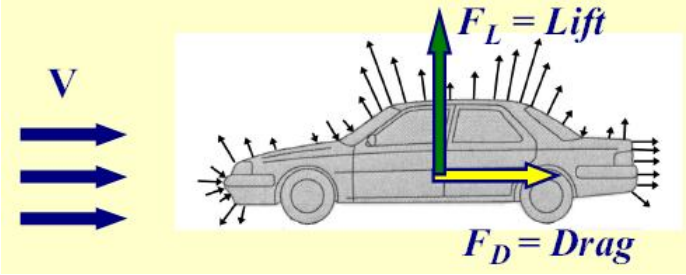

Figure 2.1 Drag and lift force due to pressure from velocity distribution [7]

2.1.2 Pressure, Lift and Drag Coefficient

Drag can generate by two main perspectives [1], firstly from the vehicle body and from the moving fluid that attached to the surface of the vehicle body. From

these two perspectives, three major coefficients were produced from the two basic of aerodynamics forces. The first force is pressure distributions that normal (perpendicular) force to the body which is will produce pressure, drag and lift coefficient. The second force is shear force that tangential (parallel) to the surface of body's vehicle where is contribute drag coefficient only [2], [3].

2.1.2.1 Pressure Coefficient

The equation for coefficient of pressure (*Cp*) due to dynamic pressure can derive as [3],[4] ;

$$Cp = \frac{p - p_\infty}{\frac{1}{2}\rho v_\infty{}^2} \tag{2.2}$$

The equation of dynamic pressure defined as [3],[4];

$$p_{tot} - p_\infty = \frac{\rho}{2} v_\infty{}^2 \tag{2.3}$$

In term of local velocity, the pressure coefficient (only valid for incompressible flow) can derive as [3],[4];

$$Cp = 1 - \frac{v^2}{v_\infty{}^2} \tag{2.4}$$

The form of equation (2.4) is from the relation equation (2.2) and equation (2.5) as shown below [2],[3],[4];

$$p - p_\infty = \frac{1}{2}\rho(v_\infty{}^2 - v^2) \tag{2.5}$$